CLAIMS

We claim:

1. A reagent dispensing apparatus comprising:

a support frame; and

a dispensing module removably attached to the support frame and comprising a self-contained pressurized fluid delivery subsystem;

wherein the fluid delivery subsystem comprises a plurality of reagent containers each being fluidly connected to a corresponding discrete fluid path terminating in a corresponding discrete dispensing tip, said dispensing tips being collectively arranged in a rectangular array, each fluid path having a corresponding dispensing device, each dispensing device being adapted to selectively dispense a corresponding reagent through the corresponding dispensing tip in response to a corresponding actuation signal.

2. The apparatus of claim 1, wherein the rectangular array comprises two or more dispensing tips.

3. The apparatus of claim 2, wherein distances between centers of the dispensing tips are calculated to correspond to a timing algorithm associated with an assay plate having known dimensions.

4. The apparatus of claim 3, wherein the distance between the centers of adjacent dispensing tips is approximately 1.50 millimeters.

5. The apparatus of claim 3, wherein the distance between the centers of adjacent dispensing tips is approximately 2.25 millimeters.

6. The apparatus of claim 3, wherein the distance between the centers of adjacent dispensing tips is approximately 4.50 millimeters.

7. The apparatus of claim 1, wherein the pressurized fluid delivery subsystem further comprises an air manifold with a port for receiving an air supply line from a source of pressurized air, and a plurality of air delivery lines extending from the air manifold, wherein each of the plurality of air delivery lines is connected to a corresponding one of the plurality of reagent containers.

8. The apparatus of claim 1, wherein each fluid path is less than approximately 25 centimeters in length.

9. The apparatus of claim 1, wherein each fluid path has a volume capacity of less than approximately 200 microliters.

10. The apparatus of claim 1, wherein each dispensing device comprises corresponding electrical leads for receiving the corresponding actuation signals.

11. The apparatus of claim 10, wherein the actuation signals are controlled by computer software.

12. The apparatus of claim 1, wherein each dispensing device comprises a corresponding solenoid.

13. The apparatus of claim 1, wherein the dispensing module is attached to the support frame using quick-release clamps.

14. The apparatus of claim 1, further comprising a motor drive system for controlling movement of an assay plate.

15. The apparatus of claim 1, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the apparatus is less than approximately 2.6%.

16. The apparatus of claim 1, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the apparatus is less than approximately 5.0%.

17. The apparatus of claim 1, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the apparatus is less than approximately 10.0%.

18. The apparatus of claim 1, wherein the fluid paths each comprise a corresponding portion supported by a common dispensing head.

19. A reagent dispensing module adapted to be removably attached to a support frame, comprising:

means for removably attaching the dispensing module to the support frame;

a platform;

a plurality of reagent containers supported by the platform, each of the plurality of reagent containers being fluidly connected to a corresponding discrete fluid path terminating in a corresponding discrete dispensing tip, the dispensing tips being collectively arranged in a rectangular array, each fluid path having a corresponding dispensing device for controlling selective dispensing of a corresponding reagent through the corresponding dispensing tip in response to a corresponding electrical signal;

an air manifold with a port for receiving an air supply line from a source of pressurized air; and

a plurality of air delivery lines connected to the air manifold, each of the plurality of air delivery lines being connected to a corresponding one of the plurality of reagent containers.

20. The module of claim 19, wherein the rectangular array comprises two or more dispensing tips.

21. The module of claim 20, wherein distances between centers of the dispensing tips are calculated to correspond to a timing algorithm associated with an assay plate having known dimensions.

22. The module of claim 21, wherein the distance between the centers of adjacent dispensing tips is approximately 1.50 millimeters.

23. The module of claim 21, wherein the distance between the centers of adjacent dispensing tips is approximately 2.25 millimeters.

24. The module of claim 21, wherein the distance between the centers of adjacent dispensing tips is approximately 4.50 millimeters.

25. The module of claim 19, wherein each fluid path is less than approximately 25 centimeters in length.

26. The module of claim 19, wherein each fluid path has a volume capacity of less than approximately 200 microliters.

27. The module of claim 19, wherein each dispensing device comprises corresponding electrical leads for receiving the corresponding electrical signals.

28. The module of claim 27, wherein the electrical signals are controlled by computer software.

29. The module of claim 19, wherein each dispensing device comprises a corresponding solenoid.

30. The module of claim 19, wherein the means for removably attaching the dispensing module to the support frame comprises quick-release clamps.

31. The module of claim 19, further comprising a motor drive system for controlling movement of an assay plate.

32. The module of claim 19, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the module is less than approximately 2.6%.

33. The module of claim 19, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the module is less than approximately 5.0%.

34. The module of claim 19, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of reagents thereinto using the module is less than approximately 10.0%.

35. The module of claim 19, wherein the fluid paths each comprise a corresponding portion supported by a common dispensing head.

36. A reagent dispensing head for use with a reagent dispensing apparatus, comprising:

a plurality of discrete fluid tubes each comprising a corresponding dispensing device for selectively dispensing corresponding reagents at corresponding dispensing tips arranged in a rectangular array, each fluid tube being connected to a corresponding discrete fluid delivery line associated with a corresponding discrete reagent container; and

a common support block for supporting the fluid tubes;

wherein the dispensing devices each comprise corresponding electrical leads for receiving corresponding electrical signals to control dispensing of corresponding reagents through the corresponding dispensing tips.

37. The dispensing head of claim 36, wherein the dispensing devices comprise corresponding solenoids.

38. The dispensing head of claim 36, wherein the rectangular array comprises two or more dispensing tips.

39. The dispensing head of claim 38, wherein distances between centers of the dispensing tips are calculated to correspond to a timing algorithm associated with an assay plate having known dimensions.

40. The dispensing head of claim 39, wherein the distance between the centers of adjacent dispensing tips is approximately 1.50 millimeters.

41. The dispensing head of claim 39, wherein the distance between the centers of adjacent dispensing tips is approximately 2.25 millimeters.

42. The dispensing head of claim 39, wherein the distance between the centers of adjacent dispensing tips is approximately 4.50 millimeters.

43. The dispensing head of claim 36, further comprising protective sleeves covering corresponding portions of the fluid tubes.

44. A method of dispensing reagents comprising the steps:

providing a reagent dispensing apparatus comprising: a support frame; and a dispensing module comprising a self-contained pressurized fluid delivery subsystem; wherein the fluid delivery subsystem comprises a plurality of reagent containers each being fluidly connected to a corresponding discrete fluid path terminating in a corresponding discrete dispensing tip, said dispensing tips being collectively arranged in a rectangular array, each fluid path having a corresponding dispensing device for controlling selective dispensing of a corresponding reagent through the corresponding dispensing tip in response to a corresponding electrical signal;

positioning an assay plate in a starting position relative to the dispensing tips in preparation for dispensing the reagents; and

dispensing the corresponding reagents through the corresponding dispensing tips into target wells on the assay plate in a switchback pattern such that each of the corresponding reagents is dispensed into each of the target wells.

45. The method of claim 44 wherein the dispensing step is conducted on-the-fly.

46. The method of claim 45, wherein the reagents are dispensed through the corresponding dispensing tips in accordance with a timing algorithm synchronized to the

switchback pattern and dependent on geometric characteristics of the assay plate, volumes of the corresponding reagents to be dispensed, and geometric characteristics of the dispensing tip array.

47. The method of claim 44 wherein the pressurized fluid delivery subsystem further comprises an air manifold with a port for receiving an air supply line from a source of pressurized air, and a plurality of air delivery lines extending from the air manifold, wherein each of the plurality of air delivery lines is connected to a corresponding one of the plurality of reagent containers, and further comprising the step of supplying pressurized air into each of the reagent containers via the corresponding air delivery lines substantially continuously during the dispensing step.

48. The method of claim 44, wherein the dispensing devices comprise corresponding solenoids.

49. The method of claim 44, wherein the rectangular array comprises two or more dispensing tips.

50. The method of claim 44, wherein the rectangular array is a 2x2 array and comprises a first dispensing tip, a second dispensing tip, a third dispensing tip, and a fourth dispensing tip, and wherein the target wells comprise a first target well, a second target well, a third target well, and a fourth target well, and wherein the dispensing step further comprises dispensing the corresponding reagents from the first, second, third, and fourth dispensing tips into the first, second, third, and fourth target wells respectively, substantially simultaneously.

51. The method of claim 49, wherein distances between centers of the dispensing tips are calculated to correspond to a timing algorithm associated with an assay plate having known dimensions.

52. The method of claim 51, wherein the distance between the centers of adjacent dispensing tips is approximately 1.50 millimeters.

53. The method of claim 51, wherein the distance between the centers of adjacent dispensing tips is approximately 2.25 millimeters.

54. The method of claim 51, wherein the distance between the centers of adjacent dispensing tips is approximately 4.50 millimeters.

55. The method of claim 44, wherein the assay plate is moved in the switchback pattern by a motor drive system controlled by computer software.

56. The method of claim 44, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus is less than approximately 2.6%.

57. The method of claim 44, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus is less than approximately 5.0%.

58. The method of claim 44, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus is less than approximately 10.0%.

59. The method of claim 44, wherein the switchback pattern is a row-skipping pattern.

60. Computer software for controlling a reagent dispensing apparatus comprising: a support frame; and a dispensing module comprising a self-contained pressurized fluid delivery subsystem; wherein the fluid delivery subsystem comprises a plurality of reagent containers each being fluidly connected to a corresponding discrete fluid path terminating in a corresponding discrete dispensing tip, said dispensing tips being collectively arranged in a rectangular array, each fluid path having a corresponding dispensing device for controlling selective dispensing of a corresponding reagent through the corresponding dispensing tip in response to a corresponding electrical signal; said software being programmed to:

position an assay plate in a starting position relative to the dispensing tips in preparation for dispensing the reagents; and

dispense the corresponding reagents through the corresponding tips into target wells on the assay plate in a switchback pattern such that each of the corresponding reagents is dispensed into each of the target wells.

61. The software of claim 60, further programmed to conduct the dispensing step is on-the-fly.

62. The software of claim 61, further programmed to dispense the reagents through the corresponding dispensing tips in accordance with a timing algorithm synchronized to the switchback pattern and dependent on geometric characteristics of the assay plate, volumes of the corresponding reagents to be dispensed, and geometric characteristics of the dispensing tip array.

63. The software of claim 60, wherein the rectangular array comprises two or more dispensing tips.

64. The software of claim 63, wherein the rectangular array comprises a first dispensing tip, a second dispensing tip, a third dispensing tip, and a fourth dispensing tip, and wherein the target wells comprise a first target well, a second target well, a third target well, and a fourth target well, and wherein the software is further programmed to dispense the corresponding reagents from the first, second, third, and fourth dispensing tips into the first, second, third, and fourth target wells respectively, substantially simultaneously.

65. The software of claim 63, wherein the distance between the centers of adjacent dispensing tips is approximately 1.50 millimeters.

66. The software of claim 63, wherein the distance between the centers of adjacent dispensing tips is approximately 2.25 millimeters.

67. The software of claim 63, wherein the distance between the centers of adjacent dispensing tips is approximately 4.50 millimeters.

68. The software of claim 60, further programmed to control a motor drive system to move the assay plate in the switchback pattern.

69. The software of claim 60, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus controlled by the software is less than approximately 2.6%.

70. The software of claim 60, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus controlled by the software is less than approximately 5.0%.

71. The software of claim 60, wherein the coefficient of variation of reagent concentration within wells of an assay plate after dispensing of the reagents thereinto using the apparatus controlled by the software is less than approximately 10.0%.